LOGISTICS INDUSTRY 4.0: CHALLENGES AND OPPORTUNITIES

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Abstract: *The frequently emerged question between logistics practitioners and theoreticians is how much technology can be leveraged to address the challenges and opportunities that arise in the logistics industry? The recently coined term - Industry 4.0 is the paradigm that explains the possibility of information and communication technologies to digitally transform processes in all industry sectors, including logistics. In this paper we are introducing a new term – Logistics Industry 4.0. Logistics Industry 4.0 refers to several emerging technologies, such as internet of things, big data, cloud computing, artificial intelligence, robotics and blockchain and their implementation in three key aspects of typical supply chain: supply of raw materials, production, and wholesale/retail and two logistics activities: transportation and warehousing. We will present the most promising technologies that will transform logistics processes in the near future and the associated challenges and opportunities.*

Keywords*: Industry 4.0, transformation of logistics processes, digitalization, Logistics Industry 4.0.*

1. INTRODUCTION

The first industry revolution introduced mechanized manufacturing with equipment powered by water and stem. The second industry revolution introduced mass production using electric energy. The third industry revolution introduced the use of electronics and computers in general to automate manufacturing. All revolutionized processed in three previously mentioned industry revolutions are related with the movement of goods (transport) and manufacturing activities which are key logistics sectors. Therefore, logistics experts can ask a question: what is the form of today's industry revolution and how it impacts logistics processes? The next industrial revolution is focused on creating interconnections between physical and virtual systems (Ilin and Groznik, 2013). This practically means the formation of global networks which shall include product and storage facilities in the form of cyber-physical systems which shall communicate independently, generate and control themselves (Maslarić et al., 2016). Thus material, information and financial flows will be transformed.

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Recently, the term – Industry 4.0 is adopted as an indication of industry change. Industry 4.0 is coined in 2011 by German engineers as an idea of a fully integrated industry (Bauernhansl, 2014). In several recent research papers the term – Industry 4.0 is primarily related to cloud computing, Internet of Things (IoT) and big data and their applications in different industries (Hofmann and Rüsch, 2017; Witkowski, 2017). However, other emerging technologies, such as robotics, Artificial Intelligence (AI) and blockchain also deserve attention because of their high potential in the process of digitalization and transformation of logistics activities. Therefore, we are introducing a new term – Logistics Industry 4.0 which encompasses previously mentioned Information and Communication Technologies (ICT) and their opportunities and challenges to digitally transform logistics processes.

The rest of the paper is organized as follows. In the second section the new term – Logistics Industry 4.0 is demystified. The related challenges and opportunities are also highlighted. In the third section implications for supply chain management are emphasized. The fourth section explains key challenges for logistics companies. The paper concludes with a key findings and implications for the future work.

2. LOGISTICS INDUSTRY 4.0: DEMYSTIFICATION

"Logistics is being transformed through the power of data-driven insights."

(Chung et al., 2018)

In logistics, data availability exponentially increases with the increased use of sensors and a key question is how to efficiently and effectively ensure data quality? Logistics companies are trying to adopt innovative IT solutions to improve intra-operational processes and achieve end-to-end visibility within supply chain.

In this section we will present the most promising digital topics that are expected to transform logistics industry in the near future. The focus is on IoT, cloud logistics, big data, AI, robotics and blockchain technology and their impact on key logistics activities (Figure 1).

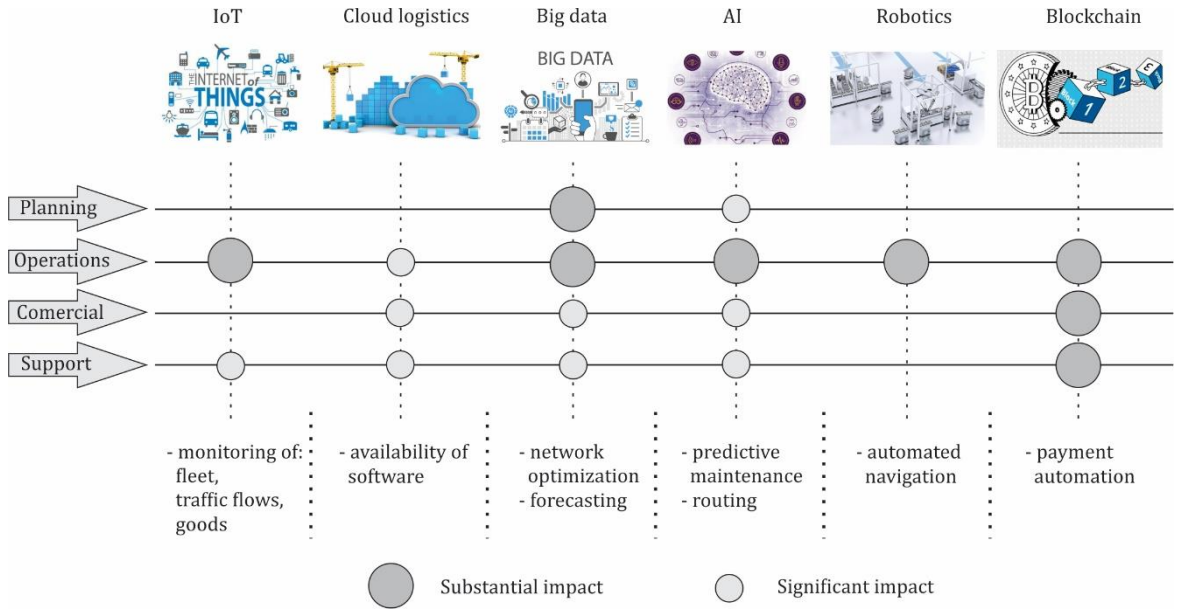

Figure 1. Impact of Industry 4.0 on logistics (adapted from Glass, 2018)

2.1 Internet of things

IoT technologies virtually connect physical objects by sensors and allow them to receive, store and send information which may improve decision-making process. In logistics, IoT can be used to enhance vehicles, infrastructure and services and deriving improvements for transport system operators and users (Lyons, 2017). According to Allied Market Research the global connected logistics market is estimated to substantially grow to $27 billion until 2023 (Allied Market Research, 2018). The key opportunity from using IoT is real-time connectivity which offers potential to improve quality of services and increase control. However, the total costs of implementation are still high and issues like security concerns and lack of legal regulation presents major concerns for decision makers in logistics companies to opt for the implementation of IoT. The development of low-cost IoT networks and decrease in sensor prices may shift the current trend.

2.2 Cloud logistics

Cloud logistics refers to new business model called Logistics-as-a-Service (LaaS). By using LaaS logistics practitioners have the opportunity to use innovative IT solution customized for logistics industry. LaaS is changing the form and function of information technology infrastructures making supply chain information collaboration easy and feasible (Ilin and Simić, 2013). LaaS also offers easier way to establish efficient and effective logistics processes which significantly decrease costs and increase time savings. A pay-per-use politics and scalability are particularly suitable for small and medium-sized logistics companies to be competitive on the market. Today, more than 50% of logistics providers use cloud-based services and a further 20% are planning to do so in the near future (Brandl, 2016). However, the three potential obstacles may inhibit LaaS adoption: security concerns, compatibility with other IT solutions within logistics company and performance issues.

2.3 Big data

Big data is the “data” characterized by the four “V”s. They are volume, variety, velocity and value. Big data has already changed logistics industry by transforming large-scale structured and unstructured data into valuable information for logistics managers during decision-making processes (Simić and Ilin, 2017). There is a huge potential in turning unused data into competitive advantage on the market. Forecasting of market demand and new business models customized for customers are some of the examples of advantages achieved by implementing big data in logistics. The advancement of big data analytics along with AI will allow real-time route optimization, holistic forecasting of fleet capacity and demand for goods and reduction of risk through the supply chain network. The biggest threats to the wider adoption of this paradigm in logistics are security issues.

2.4 Artificial intelligence

AI technology is an integral part of almost every IT system today. It is closely related with IoT technology which allows data collection by sensors, cloud computing technology and big data paradigm. AI can be observed as a set of technologies interrelated with the aim to solve complex problems. Typically, AI technology consists of three types of components: sensing, processing and learning. Sensing components refer to data obtained

(usually by sensors) from the physical world. Processing components refer to set of algorithms implemented in various software solutions with the aim to process data. Learning components refer to capturing patterns of structured and unstructured data. In logistics, AI can provide optimal solutions for vehicle routing and consequently cost reduction, ensure predictive forecasting for demand, accelerate decision-making and increase customer satisfaction through the personalization of logistics services. The strongest challenge is high implementation costs for a logistics company.

2.5 Robotics and automation

Robotics is a science field closely related with AI and further with IoT, cloud computing and big data. Robotics has a great potential to be implemented in dynamic environments, such as production and warehousing. According to a DHL research, 80% of warehouses are manually operated today (Bonkenburg, 2016), which leaves plenty of opportunities for automation. In highly automated warehouses autonomous vehicles are used for the realization of transport processes. Autonomous vehicles provide higher speed, precision, safety and tracking capability than to forklifts, hand pallet trucks and high rack pallets (Gu et al., 2007). Also, autonomous vehicles can be reprogrammed, permanently operational without human intervention, modular and easily integrated with other robots and devices. Compared to traditional warehouses, highly automated warehouses provide a high degree of flexibility and lack of the need for installation of fixed infrastructure (Vis, 2006). However, significant resources need to be invested in the implementation. Still, technological advances may decrease required resources in the near future.

2.6 Blockchain

A blockchain is a decentralized, distributed and public digital ledger that is used to record transactions across many computers so that any involved record cannot be altered retroactively, without the alteration of all subsequent blocks (Economist, 2015). Blockchain technology basically allows shift from a centralized to a decentralized and distributed database system. The greatest potential of its application in logistics lies in global trade, where solutions that reduce supply chain trade barriers can increase global GDP by nearly 5% and global trade by 15% (Moavenzadeh, 2013). The potential advantages also include increased transparency, traceability and speed of goods deliveries, decreased overall costs and digitalization of all key documents (such as invoice) with stakeholders participating. However, since logistics industry is highly fragmented the adoption of blockchain technology in various industries will be very costly and unpredictable. Also, legislation regarding this subject need to be defined more thoroughly in the near future.

3. LOGISTICS INDUSTRY 4.0: IMPLICATIONS FOR SUPPLY CHAIN MANAGEMENT

The following conceptualization shows in which direction the transformation of supply chain management will occur (Figure 2). There are digital and physical world and interconnections between them. In virtual world this concept implies an integration of data networks and ICTs and in the physical world this means establishing personalized transport services and optimized distribution of goods. Autonomous vehicles and robots are some of the examples of innovative ICT solutions that enable self-control of logistics subsystems and their mutual interconnections. Sensor data are collected in the physical

world along the entire closed-loop supply chain. Traditional technologies, such as radio-frequency identification or global positioning system, also produce a vast amount of data. Furthermore, there are other data sources relevant to Supply Chain Management (SCM) (e.g. digital clickstreams, camera and surveillance footage, imagery, wikis and forum discussions) that usually produce unstructured data. In total, there are tremendous amount of data that need to be processed instantly. Through the connectivity layer data analytics improve decision-making and add value to logistics services (Figure 2).

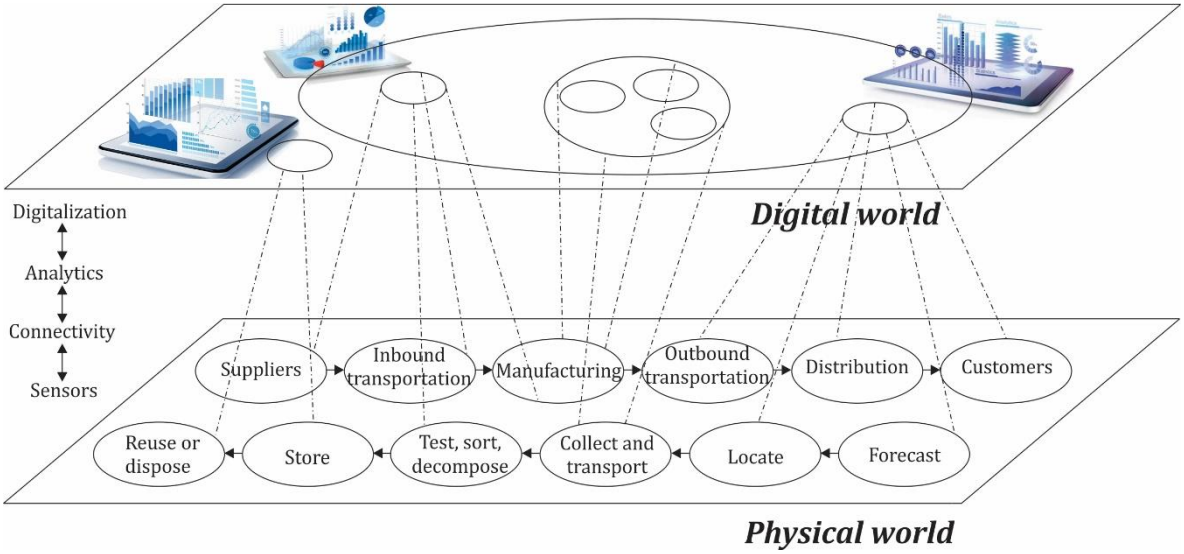

Figure 2. Transformation of supply chain management

3.1 Implications from theory

In previous research papers the concept Industry 4.0 in logistics have been investigated in specific intra-logistics areas, such as production logistics (Qu and Liu, 2015) and cross-organizational concepts, such as just-in-time, just-in-sequence and Kanban (Hofmann and Rüsch, 2017). Our selection is based on three key aspects of typical supply chain: supply of raw materials, production, and wholesale/retail and two logistics activities that connects previously identified aspects: transportation and warehousing. The authors used the publication databases SCOPUS, Web of Science and Google Scholar to highlight the importance of previously mentioned concepts. The databases were searched with respect to publications with a clear reference to the concepts in either their title, abstract or keywords. The obtained search results are presented in Table 1.

Table 1. Search string results

Supply chain management	*SCOPUS (title, abstract or keywords)*	*Web of Science (title only)*	*Google Scholar (title only)*
supplier	103	0	3
production	1625	73	208
wholesale/retail	1/15	0/0	0/0
transport	72	2	7
warehouse	42	5	8

It can be noticed (Table 1) that the term – Industry 4.0 is frequently used in research papers that deal with industrial production. There is also a lack of research papers that explain the relationships between Industry 4.0 and suppliers, wholesalers, retailers as well as transportation and warehousing activities. Therefore, the production sector is more appropriate to be discussed in the context of Industry 4.0 than other SCM subsectors. If we further make a search for journal articles and conference papers that contain both keywords "Industry 4.0" and "production" in title we can identify the increase in the number of research papers that are published each year (Figure 2).

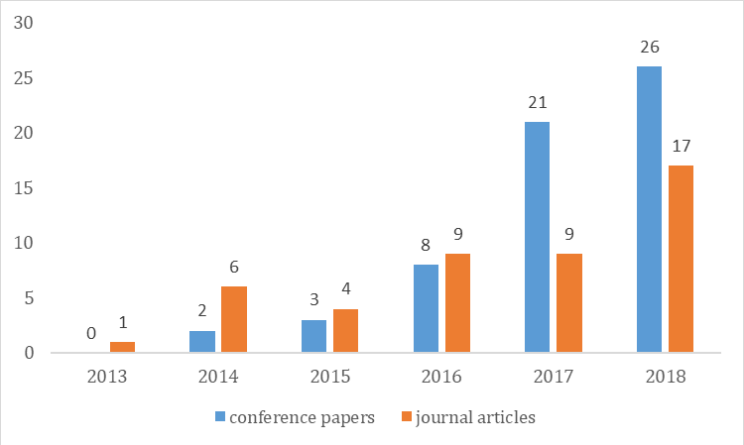

Figure 2. Number of published research papers that contain keywords "Industry 4.0" and "production" in title in the last six years (source: SCOPUS)

Industry 4.0 is particularly important in the context of production planning and control. These contexts share the idea of assigning tasks of production control to "intelligent" objects, such as machines, parts, and products, in order to attain higher flexibility, higher adaptability, and therefore a higher logistics performance (Bendul and Blunck, 2019). Smart production is another concept that relies on Industry 4.0. For example, glass recycling industry empower Industry 4.0 to obtain decision-making information systems and data-driven innovation (Lin, 2018). Another example is intelligent sustainable supplier selection using multi-agent technology. It is found that the previously mentioned approach can help decision-makers inside manufacturing firms to make prompt decisions with less human interactions (Ghadimi et al., 2019).

Industry 4.0 has a potential to be applied in smart transportation and smart warehousing. Smart transportation refers to transformation and redesign of cities' infrastructure. This is particularly related with smart cities, intelligent transport systems and transportation management systems (Schlingensiepen et al., 2016). Smart warehousing refers to efficient data collection, accurate and robust localization, human activity recognition and multi-robot collaboration (Liu et al., 2018).

4. LOGISTICS INDUSTRY 4.0: KEY CHALLENGES

Logistics Industry 4.0 concept has numerous opportunities to transform logistics industry by data-driven insights. The explosion in data size is inevitable today due to necessity for data collection from multiple sources, including autonomous vehicles, robots and other "smart" machines. We have highlighted three key challenges for logistics companies:

1. **Data collection, storage and processing**. With a constant increase in the amount of generated structured and unstructured data, the need for different ways for data storage and processing is also growing. Investments in innovative ICT solutions equipped with sensors are growing with the increase in their additional performances and in their capacity to collect, store and transmit data. New algorithms and models are constantly being developed. Decentralized database for data storage are being replaced with a centralized database systems. However, there is still a lack of regulations for data management. As a result, redundant date is stored in different sectors of the company and additional costs are needed to eliminate them as much as possible.
2. **Data security and lack of standards**. In a complex and highly fragmented logistics industry companies need to share data constantly to keep logistics processes optimized. One of the advantages is to keep the stock level at minimum. However, security issues are major concern for decision makers. A security breach may be defined as an incident in which a logistics company loses sensitive data. Unauthorized access to sensitive data may cause high costs from more than one perspective. For example, production plan may need to be reevaluated and trading partners may lose trust. Security standards and norms are also a condition of achieving a high number of network partners. Without regulations small and medium-sized companies will have to adapt to standards of the large company of which they are a supplier.
3. **Lack of digital strategy**. Along supply chain (and value creation chain as well) data need to be vertically and horizontally integrated and available for all parties involved. Vertical integration refers to the integration of various ICT solutions into a complex information system. Horizontal integration refers to the integration of processes between stakeholders along supply chain. This includes exchanging of data between different sectors (such as supply, production and sales) of several logistics companies along the entire closed-loop supply chain. Therefore, significant institutional and corporate investments need to be implemented to achieve digital supply chain in the back-end.

5. CONCLUSION

Industry 4.0 will reshape the logistics industry in the way that many processes will be digitally transformed. When new technology is introduced in a company resistance of change is almost inevitable due to need for transformation of processes and working habits. Key challenges facing the progress of digital topics in logistics include high costs of technology, lack of trust in data security and lack of regulations and standards. According to authors' opinion the lack of trust in data security will be more difficult to deal with because it introduces risks and uncertainties.

In this paper we have analyzed only a few innovative ICT solutions. There are many other digital topics, such as unmanned aerial vehicles, 3D printing and augmented reality, that also deserve attention. Future research should be directed in their demystification and potential application in logistics processes.

Very important question related with the paradigm Logistics Industry 4.0 is what changes logistics experts, workers and other employees in transportation, distribution and

manufacturing companies will be "forced" to accept? According to authors' opinion the changes will primarily be related to necessity to accept new skills and knowledge that was not equally important for logistics experts before. Good computer knowledge (including programming skills) is already inevitable expertise for many logistics experts. And many more will come. Future research should deal with this aspects.

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